International Seminar on Status and Prospects for Small and Medium Sized Reactors, held in Cairo, Egypt, 27 – 31 May, 2001

Summary

At the end of 2000, 438 nuclear power plants were operating in 30 countries with a total capacity of 351 GWe. The global nuclear share of electricity was 16.1%. Much of the nuclear share is concentrated in industrialized countries, but a number of developing countries have already deployed nuclear power projects and some are considering doing so. During the early years of nuclear power deployment, in the 1950s and 1960s, the plants were dominated by what are now considered small (less than 300 MWe) and medium-sized (300 to 700 MWe) reactors. Then in 1970s and 1980s many large reactors (700 MWe to 1500 MWe) were constructed. However, since the early 1990s, the interest of developing countries, mainly in Asia, has resulted in increased efforts on the design of small and medium sized power reactors. Also, in industrialized countries, electricity market deregulation is calling for power generation flexibility that smaller reactors may offer. Small and medium reactors (SMRs) are also of particular interest for non-electric applications such as seawater desalination and district heating, and, in the future, hydrogen production. In the next 50 years, electric demand is expected to be tripled, most of which will come from developing countries. In light of this, IAEA organized the "International Seminar on Status and Prospects for Small and Medium Sized Reactors" in Cairo, Egypt during May 27 – 31, 2001. The objective of the Seminar was to provide a forum for the exchange of information by experts and policy makers from developed and developing countries on the technical, economic, environmental, and social aspects of SMR development and implementation in the 21st century, and to make this information available to all interested Member States.

Two hundred forty seven attendees from 39 countries and 5 international organizations participated at the Seminar. One hundred and eighty nine of these came from developing countries and 45 from developed countries with 13 from the international organizations.

The Seminar and the accompanying Exhibit were opened by a distinguished group, which included the Minister of Electricity and Energy of Egypt and the Director Generals of the IAEA, OECD/NEA and the World Nuclear Association. The Egyptian Minister conveyed the message on nuclear energy for the developing countries on behalf of the Prime Minister of Egypt, which emphasized: (1) long-term commitment of the country for nuclear energy, (2) transfer of nuclear technology from the developed world, (3) the importance of and commitment to safety, (4) reduction of the high cost of development and investment, (5) dealing with the waste and back-end fuel-cycle issues and (6) enhancement of public acceptance.

IAEA Director General, Dr. Mohamed ElBaradei, said that innovation, adaptability, and collaboration are keys to success for the SMRs. With the advent of telecommunications and the global marketplace, the world has become a much smaller place, and the demand for a higher standard of living is increasing everywhere — yet an estimated two billion people still lack access to electricity. Dramatic increases in electricity demand are expected over the next several decades — with the growth rate in developing countries expected to be three times faster than in industrialized countries. To meet this growth — inevitable for economic and social development — he contended that a total reliance on fossil fuels and large hydroelectric facilities is not sustainable, and an expanded future role of nuclear power must be considered. Dr. ElBaradei said the future of nuclear power depends upon success in meeting four basic

challenges. The first challenge is to develop clear national and international strategies for the disposal of high level nuclear and radioactive waste. The second challenge is to remain vigilant in ensuring the continued safety of operations at nuclear facilities. The third challenge involves outreach to civil society — engaging the public and decision makers in a fair evaluation of the relative merits of the different energy options. The fourth challenge entails the development of new, innovative reactor and fuel cycle technologies. To be successful, these new technologies should incorporate inherent safety features, proliferation resistant characteristics, and reduced generation of waste. They must also be capable of generating electricity at competitive prices while satisfying both regulators and investors.

OECD/NEA Director General, Mr. Louis Echavarri emphasized that the beginning of the 21st century is characterised by significant changes in the energy policy-making framework of most countries. Globalisation of the world economy, deregulation of electricity markets, privatisation of the electricity sector, increasing concerns about the need to protect the environment and awareness of sustainable development goals are among the major trends affecting policy making and decisions in the energy sector. All those factors have impacts on nuclear energy programmes and may affect SMR development in particular. National energy policies are based upon country specific contexts and priorities but the main driving factors in energy policy making are similar world-wide. The evolution of energy supply mixes and the rate of change between alternative sources or technologies have been driven by a limited number of factors relating to economic development and competitiveness, as well as social and environmental protection issues. Although recent trends place emphasis on market mechanisms to ensure competitiveness, governments, especially in OECD countries, are increasingly considering an integrated approach to policy making, within a sustainable development framework, incorporating economic, social and environmental dimensions.

WNA Director General, Mr. John B. Ritch III, announced the new charter of the World Nuclear Association (formerly Uranium Institute) as an organization representing the nuclear industries and that its membership is being enlarged. It will provide a global nuclear forum and a commercial and technical meeting place for those engaged in nuclear power. He very aptly said that Egyptians as a nation and people stand at the bridge-point between the many separations in our world – between past and future, North and South, East and West, poor and wealthy, developed and developing – and in the realm of nuclear affairs, between those nations with nuclear energy and those without. So, it was particularly appropriate that a seminar on the future of nuclear power was held in Cairo.

The Seminar was organized in a series of 13 sessions, which included 3 panel discussions and contained a total of 82 speakers in addition to the 4 opening addresses. The panels discussed challenges of SMR deployment, incentives for introduction of SMRs in developing countries and solutions leading to increased deployment of SMRs. Separate sessions dealt with economics and financing, non-proliferation fuel cycles issues, reactor designs and applications.

A significant item, stressed at the very beginning, was that the population growth of the world has been decelerating since 1990, and the world population may barely reach 8 billion around 2050 and it may start to decline shortly thereafter; virtually all of the 21st century's population growth will occur in developing countries. The population will concentrate around cities and the number of Mega Cities with 15 million or more people will increase from 5 to

15 and all in developing countries. It was said that if nuclear energy cannot play a role in the developing countries, it is destined to be a sideshow in the global energy picture.

Competitiveness remains a cornerstone in energy policy making, but the framework within which comparative economic assessments are conducted is evolving. Increasing emphasis is placed on market mechanisms for promoting optimised energy supply mixes, in particular for electricity generation. The key factors affecting the economic competitiveness of alternative electricity generation sources and technologies are essentially fossil fuel prices, capital costs, expected rates of return on investments, and technological performance, e.g., thermal efficiency, availability factor and technical lifetime of power plants. In particular, combined cycle gas turbines, which are the main competitor for SMRs at present, may lose most of their competitive margin if gas prices continue to rise.

Regarding economic and financial aspects, total capital cost is lower for SMRs than for large size units, even if their specific cost per MWe installed is generally higher. Therefore, SMRs are likely to be easier to finance by private investors and/or in countries with limited capital availability. It remains that competitiveness with alternatives, including fossil-fuelled power plants, renewable energy sources and large nuclear units, will be a prerequisite for the deployment of SMRs. In order to compensate for the lack of economy of scale, designs should place emphasis on simplification and modularity allowing for fabrication in series of most elements of the plants. Shortening of construction time could be a key factor in reducing the total capital cost and thereby enhancing competitiveness.

SMRs are adapted to decentralised energy demand and their deployment may be feasible in various market conditions where large nuclear units would have difficulties to compete. Generally, in order to ensure grid stability, the size of the largest unit on a network should not exceed 10% of the total interconnected capacity. The trend to industrialisation and urbanisation in developing countries increases the demand for electricity in regions where grids are rather small. SMRs are well adapted to those circumstances where the introduction of large nuclear units would not be possible.

The increasing awareness of environmental issues and more broadly the sustainability goals, including long-term security of supply and protection of people and eco-systems, are giving a stronger weight to non-economic criteria in energy policy making. Explicitly integrating the concept of sustainable development in energy policies is calling for strategies that preserve natural resources and the environment, reduce regional disparities and give equal opportunities to present and future generations world-wide. From this point of view, nuclear energy, including SMRs, may be viewed as a key option to implement in sustainable energy supply mixes because it is a carbon-free energy source that relies on plentiful natural resources, uranium and thorium, that have no other significant commercial use. On the other hand, concerns raised by long-lived radioactive waste disposal and low probability/high consequence nuclear accidents are social and political hurdles that need to be overcome in order to secure a future role for nuclear energy and possibilities for the deployment of SMRs.

SMRs can be used to supply heat and electricity, or heat only, for industrial applications and district heating. Their advantages over large nuclear units for this type of application, besides the better adaptation of their size to the demand, are linked with safety characteristics

allowing them to be sited in densely populated areas. Although only a few nuclear units in operation in the world are used for district and/or process heat generation, they demonstrate that other applications of nuclear energy are already possible. The use of SMRs for seawater desalination deserves specific attention in the light of its importance in a number of countries where potable water shortages are already experienced or expected to occur in the near future. Nevertheless, finding adequate sites and gaining public acceptance may remain difficult as well as reaching competitiveness with alternative options. Finally, nuclear energy could play a significant role for large-scale production of hydrogen, if and when hydrogen becomes a major secondary energy carrier.

The latest status of many SMR designs was presented. Twenty-six new and innovative SMR designs (12 water cooled reactors, 5 gas cooled reactors and 9 liquid metal cooled reactors) were presented in some detail at the technical sessions. Among the LWRs the following was the country breakdown: Russia- UNITHERM, VK-300, RUTA-55, KLT-40, ABV-6; USA - IRIS; Japan - PSRD and SSBWR; Argentina - CAREM; ROK - SMART; India - AHWR; and Canada - NG CANDU. With regard to gas-cooled reactors, PBMR (South Africa), HTTR (Japan), HTR-10 (China), GT-MHR (US-Russia-France-Japan) and a direct cycle carbon dioxide cooled fast reactor from Japan were presented. The country breakdown for the liquid metal cooled reactors was the following: USA - ENHS; Japan - MPFR, LSPR, MDP and 4S; Russia - MBRU-1.5, BMRU - 12, BMN-170 and SVBR-75.

Key features of SMRs include simplification and streamlining of designs as well as emphasis placed on safety features avoiding off-site impacts in case of accident. Such characteristics should facilitate their acceptability by local communities.

Several countries and groups are working on innovative reactor technology development. Particularly two international groups – the US-initiated Generation IV International Forum (GIF) and the IAEA-initiated International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO) - are currently working on innovative reactors for the future. The time frame of interest to the GIF is two or three decades from now, and their interest is development of suitable technology (reliable and safe, sustainable, and economic) and the R&D effort needed to accomplish the goals. INPRO is mainly focusing on developing user's requirements for nuclear power for the long term – fifty years time frame. The INPRO developed criteria are expected to be used by individual countries to assess their situation with respect to nuclear power introduction or expansion.

The subject of non-proliferation was discussed in some detail. In spite of the demonstrated effectiveness of the international safeguards regime, the risk of proliferation of nuclear weapons remains a social and political concern deserving to be addressed by governments and the nuclear industry. A significant deployment of SMRs would lead to building a large number of reactors in many different countries and sites. Therefore, gaining social acceptance will require specific efforts of designers to enhance the proliferation resistance characteristics of SMRs. It was stressed that we must remain more vigilant and the suppliers, verifiers and buyers must assure safeguarding of nuclear materials. It was also said that it would certainly be desirable to have new, more proliferation-resistant technology, but given the existing technology, we surely have the international, scientific and regulatory

mechanisms to handle the proliferation question and we should move forward as rapidly as possible to build nuclear power where it can meet human and environmental needs.

Effective regulation is a key element. Safety should be enhanced by multi-dimensional approaches including maintenance, operation, and good management practices. Key issues raised and discussed include the need to incorporate safety goals and requirements at the earliest possible stage of concept and design activities and to enhance the dialogue between designers and regulators to avoid delays in the licensing process, in particular for innovative designs. The importance of international co-operation aiming at harmonizing safety goals and requirements was stressed with emphasis on the role of international organizations. For example, if a new design could be licensed for use in one country based on internationally accepted safety goals and requirements, then it could reduce elaborate, repetitive licensing efforts in other countries; it would help implementing nuclear power projects more economically.

A common theme that emerged from the Seminar was the importance of establishing the necessary infrastructure (including qualified manpower) to support nuclear power introduction and to optimize local participation. Infrastructure and lack of finance were considered significant constraints to the introduction of nuclear power in developing countries.

A major interest of the participants at the Cairo Seminar was cost-effective and stable electricity generation for normal use and not for remote, specialized operation. The participants were mostly interested in near term nuclear plants; the time horizon was certainly within 2020 if not less, and hence the interest was not toward what R&D efforts are needed but rather what could be available in the near future and what needs to be done to build nuclear plants. The time frame for the availability of commercial SMRs is very important as most developing countries could not wait for another two or three decades to increase their installed electricity generation capacities. A combination of technical and managerial improvement is the way to go. The importance of long-term continuity of nuclear energy policy of a country was also emphasized.

Energy markets of the 21st century will be challenging for all technologies and emerging options such as SMRs may have difficulties entering the commercial phase in the light of the emphasis placed by investors on short-term benefits. However, governments of countries wishing to keep the nuclear option in the framework of sustainable energy mixes for the future may consider supporting further research and development on SMR concepts.

There was a consensus on one point: everyone agreed that a new SMR must be demonstrated first, preferably in the country of origin, before another country will buy one. No country wanted to be “a guinea-pig” for a new design.